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ABSTRACT

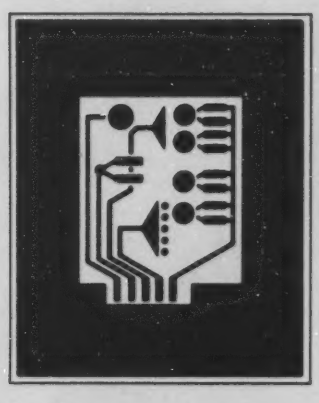
The results of a five-step curriculum analysis of the electronics program at Fresno City College, California, are provided in this booklet. (An analysis of four other vocational programs are provided in CE 019 817-820.) The products of step 1 include a definition of the employment opportunity for this area and a statement of the skills/behaviors/attitudes required for employment; program curriculum objective defined specific to the stated employment requirements; performance requirements for the stated program curriculum objective; curriculum objectives of all existing vocational/occupational courses presently required for graduation from this program area; and a definition of the terminal mastery (cognitive/affective/psychomotor) which students must achieve from each non-occupational/vocational course included in the program. Step 2 includes a cognitive/affective/psychomotor analysis of each stated course objective and the criteria of mastery for each item identified. Step 3 includes an identification of items of mastery required in each course which represent problem areas for the disadvantaged student; and a diagnosis/identification of the nature of the problem areas and their perceived causes in terms of student-related and curriculum/course-related causes. Step 4 includes a restatement of the priority problem area as terminal performance objectives, criterion measures for each terminal performance objective, learning requirements to achieve each objective, an organization of learning stress, and an analysis of alternate methods and media. Finally, step 5 includes specific recommendations of program/course change to eliminate identified problems and produce the required mastery. (JH)

ED166458

"Project: MOBILITY"

A Federally Funded Research and Design Project
for
Disadvantaged and Handicapped Vocational Education Students
(Grant #G007603888)

THE FOLLOWING IS A CURRICULUM ANALYSIS
COMPLETED TO
IDENTIFY AND ELIMINATE HURDLES TO STUDENT SUCCESS IN



Electronics

Curriculum Analysis

Curriculum Committee:

Mr. Charles King, Chairperson
Mr. Gilbert delaLaing
Mr. Cecil Lindsey
Mr. Charles Lynes

Committee Consultants:

Ms. Betty O. Corrigan
Mr. Ward L. Corrigan

Project Director:

Mr. Richard Handley
Associate Dean of Instruction
for Occupational Education

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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CE 019817

June, 1978

Fresno City College..1101 E. University Ave..Fresno, CA - 93741..(209) 442-4600

RESEARCH AND DESIGN PROJECT
CURRICULUM ANALYSIS

ELECTRONICS

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RESEARCH AND DESIGN PROJECT

CURRICULUM ANALYSIS

INTRODUCTION

The largest task undertaken in completing Phase II of this project was the thorough curriculum assessment of the five vocational education programs focused on by this project (Automotive Mechanics, Electronics, Licensed Vocational Nursing, Registered Nursing and Office Occupations). This analysis sought to identify the specific hurdles which were preventing student success; and then to determine what specific instructional methods/media changes would have to be made to eliminate them.

Each team worked to translate their curriculum from a norm referenced to a criterion referenced basis. Employment requirements replaced textbook tables of content as the basis of determining what should be mastered. Individual mastery replaced class standing as the standard of success or failure; and the methods and media of instruction were reassessed to determine if they were most appropriate, given the unique needs of the target students and the characteristics of the skills/knowledges/attitudes to be mastered.

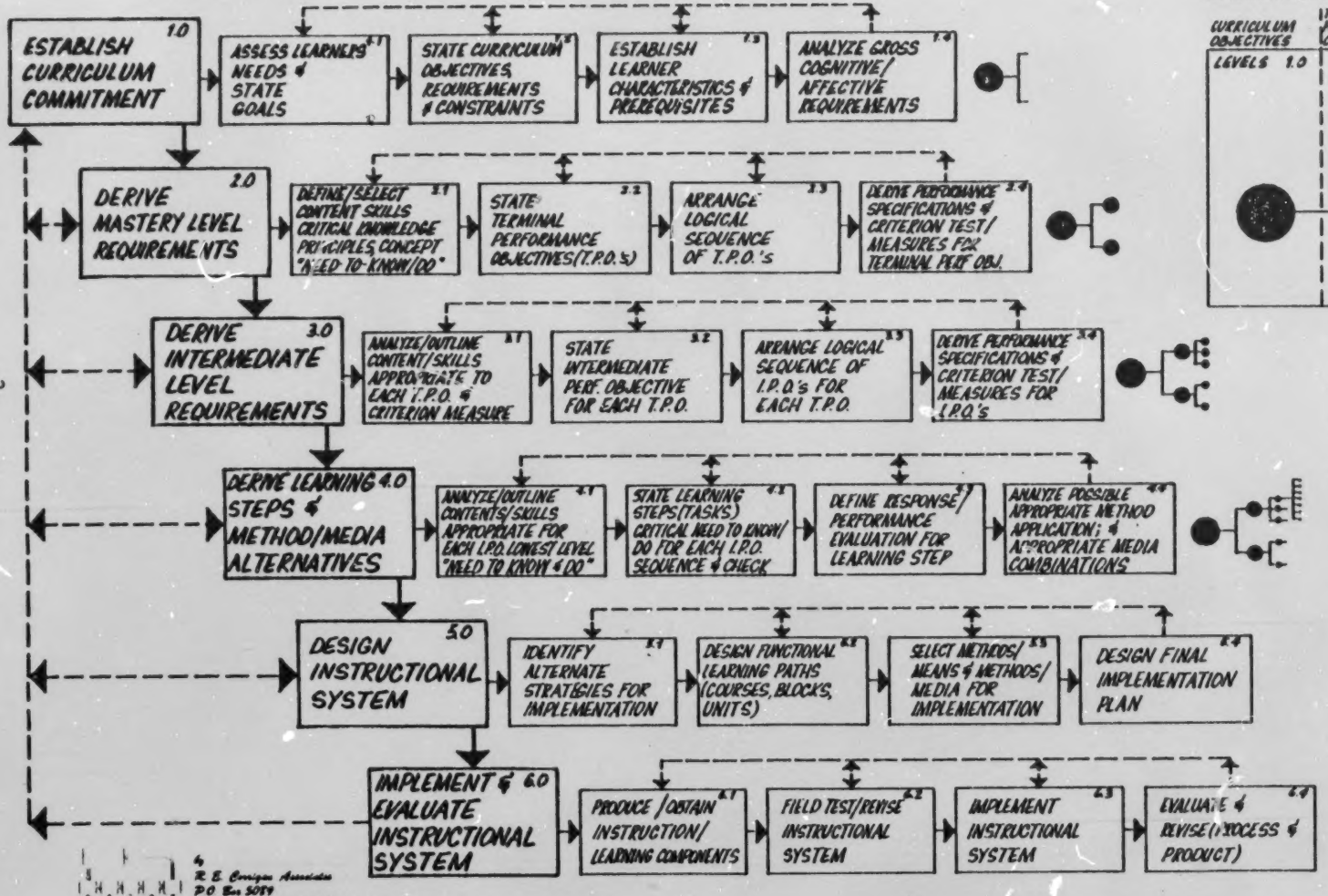
The process used by each team was a highly systematic one. It sought to eliminate assumption and to standardize the curriculum analysis steps being applied by each of the five instructional design teams. All teams applied the same steps, in the same sequence, and against the same standards of completion. As much as possible, the process remained a constant. It was only the content/skills/behavior being analyzed that differed from team to team. The model of curriculum analysis that was employed can be found on page 3. All team members

were trained in its application. In addition, a consultant from the developers of the model worked with each design team as they applied it to their vocational education program.

There were five general steps applied by each team. A listing of those steps can be found on pages 5 and 6. This booklet has been sectioned and bound according to those five steps. At the beginning of each section, you will be provided with a general overview of what the team did at that step. You will then be given a listing of the analysis functions performed by the team at that step. For steps 3 and 4, you will also be provided with the detailed instructions given to the team and copies of the forms they used. The curriculum analysis products developed by the team will then be provided in the sequence in which they were developed.

We hope that our effort will be of value and that the following analysis will help eliminate the hurdles which are keeping disadvantaged and/or handicapped vocational education students from successfully acquiring the skills, knowledges and attitudes they require to enter the job market place and; as a minimum, achieve their independant survival point.

SAFE INSTRUCTIONAL SYSTEM MODEL


1.0 ESTABLISH CURRICULUM COMMITMENT
1.1 ASSESS LEARNERS NEEDS & STATE GOALS
1.2 STATE CURRICULUM OBJECTIVES, REQUIREMENTS & CONSTRAINTS
1.3 ESTABLISH LEARNER CHARACTERISTICS & PREREQUISITES
1.4 ANALYZE GROSS COGNITIVE/AFFECTIVE REQUIREMENTS
2.0 DERIVE MASTERY LEVEL REQUIREMENTS
2.1 DEFINE/SELECT CONTENT SKILLS CRITICAL KNOWLEDGE PRINCIPLES, CONCEPT "NEED TO-KNOW/DO"
2.2 STATE TERMINAL PERFORMANCE OBJECTIVES (T.P.O.'S)
2.3 ARRANGE LOGICAL SEQUENCE OF T.P.O.'s
2.4 DERIVE PERFORMANCE SPECIFICATIONS & CRITERION TEST/MEASURES FOR TERMINAL PERF OBJ.
3.0 DERIVE INTERMEDIATE LEVEL REQUIREMENTS
3.1 ANALYZE/OUTLINE CONTENT/SKILLS APPROPRIATE TO EACH T.P.O. & CRITERION MEASURE
3.2 STATE INTERMEDIATE PERF. OBJECTIVE FOR EACH T.P.O.
3.3 ARRANGE LOGICAL SEQUENCE OF I.P.O.'s FOR EACH T.P.O.
3.4 DERIVE PERFORMANCE SPECIFICATIONS & CRITERION TEST/MEASURES FOR I.P.O.'s
4.0 DERIVE LEARNING STEPS & METHOD/MEDIA ALTERNATIVES
4.1 ANALYZE/OUTLINE CONTENTS/SKILLS APPROPRIATE FOR EACH I.P.O. LOWEST LEVEL "NEED TO KNOW & DO"
4.2 STATE LEARNING STEPS (TASKS) CRITICAL NEED TO KNOW/DO FOR EACH I.P.O. SEQUENCE & CHECK
4.3 DEFINE RESPONSE/PERFORMANCE EVALUATION FOR LEARNING STEP
4.4 ANALYZE POSSIBLE APPROPRIATE METHOD APPLICATION; & APPROPRIATE MEDIA COMBINATIONS
5.0 DESIGN INSTRUCTIONAL SYSTEM
5.1 IDENTIFY ALTERNATE STRATEGIES FOR IMPLEMENTATION
5.2 DESIGN FUNCTIONAL LEARNING PATHS (COURSES, BLOCKS, UNITS)
5.3 SELECT METHODS/MEANS & METHODS/MEDIA FOR IMPLEMENTATION
5.4 DESIGN FINAL IMPLEMENTATION PLAN
6.0 IMPLEMENT & EVALUATE INSTRUCTIONAL SYSTEM
6.1 PRODUCE/OBTAIN INSTRUCTION/LEARNING COMPONENTS
6.2 FIELD TEST/REVISE INSTRUCTIONAL SYSTEM
6.3 IMPLEMENT INSTRUCTIONAL SYSTEM
6.4 EVALUATE & REVISE (PROCESS & PRODUCT)
CURRICULUM SYNTHESIS
CURRICULUM ANALYSIS LEVELS
CURRICULUM OBJECTIVES
TERMINAL PERFORMANCE OBJECTIVES
INTERMEDIATE PERFORMANCE OBJECTIVES
LEARNING STEPS METHOD/MEDIA ALTERNATIVES
LEVELS 1.0 2.0 3.0 4.0

R E Corrigan Associates
P O Box 5019
Anaheim California 92804

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CORRIGAN ASSOCIATES

P.O. BOX 5089, ANAHEIM, CALIFORNIA 92804 - (714) 539-4359

RESEARCH AND DESIGN PROJECT

SPECIFIC WORK ASSIGNMENTS TO BE COMPLETED BY EACH CURRICULUM DESIGN TEAM.

The following five steps will constitute the total scope of work to be completed during Phase II of the project. Establish your own work schedules and meeting times. All work is to be completed by December 16, 1977.

STEP 1

a) Derive Employment Requirements - a definition of the employment opportunity and a statement of the Skills/Behaviors/Attitudes required for employment.

b) Define your Program Curriculum Objective specific to the stated Employment Requirements - focus on required final mastery.

c) Derive Performance Requirements for the stated Program Curriculum Objective. These represent statements of all operating limitations, conditions or givens affecting the implementation or content of the Program Curriculum Objective.

d) Translate all existing courses presently required for graduation from your program area into curriculum objectives (vocational/occupational courses only).

e) Define the terminal mastery (Cognitive/Affective/Psychomotor) which students must achieve from each non-occupational/vocational course included in your program.

STEP 2

a) Perform a Cognitive/Affective/Psychomotor Analysis of each stated course objective to derive ALL highest levels of mastery required for successful completion of the course.

b) State the criteria of mastery for each item identified in the Cognitive/Affective/Psychomotor Analysis. These statements would include the method of evaluation and the level of performance required of the student (How and How Well). This statement is not the exact test item that the student would encounter (Criterion Measure).

c) Assess each course to confirm that the sequencing of the items of mastery is correct according to the taxonomies; and that the combined courses will produce the mastery demanded by the Employment Requirements and the Program Curriculum Objective (vocational/occupational courses only).

STEP 3

a) Identify those items of mastery required in each course which represent problem areas for the disadvantaged student; i.e., required proficiency levels

not being attained.

b) Diagnose/Identify the nature of the problem areas and their perceived causes for performance deficiencies in terms of 1) student related and 2) curriculum/course related causes.

c) Prioritize the identified problem areas according to their criticality for continuing success by the disadvantaged student.

STEP 4

a) Restate the priority problem areas as Terminal Performance Objectives.

b) Derive Criterion Measures for each Terminal Performance Objective.

c) Analyze the Learning Requirements to Achieve each Objective.

d) Organize the learning steps.

e) Analyze alternate Methods and Media.

STEP 5

a) Define specific recommendations of program/course change to eliminate the identified problems and produce the required mastery.

RESEARCH AND DESIGN

PROJECT: MOBILITY

STEPS OF CURRICULUM ANALYSIS

STEP 1

AS THEIR FIRST STEP, THE DESIGN TEAM SEEKS OUT THE EMPLOYER'S STATEMENT OF SKILLS/KNOWLEDGES/ATTITUDES REQUIRED FOR EMPLOYMENT. THE COLLEGE'S VOCATIONAL PROGRAM AND ITS COURSES ARE THEN TRANSLATED INTO MEASURABLE PERFORMANCE OBJECTIVES.

THIS STEP CLEARLY DEFINES THE SKILLS/KNOWLEDGES AND ATTITUDES REQUIRED FOR EMPLOYMENT WHICH WILL BE THE ULTIMATE REFERENT FOR THE ENTIRE PROJECT. IT ALSO TRANSLATES THE COLLEGE'S VOCATIONAL EDUCATION PROGRAMS INTO MORE PRECISE STATEMENTS OF REQUIRED FINAL MASTERY. THIS FINAL MASTERY WILL BE THE TARGET OF ALL UPCOMING CURRICULUM ANALYSIS STEPS.

STEP 1:

A) DERIVE EMPLOYMENT REQUIREMENTS - A DEFINITION OF THE EMPLOYMENT OPPORTUNITY AND A STATEMENT OF THE SKILLS/BEHAVIORS/ATTITUDES REQUIRED FOR EMPLOYMENT.

B) DEFINE YOUR PROGRAM CURRICULUM OBJECTIVE SPECIFIC TO THE STATED EMPLOYMENT REQUIREMENTS - FOCUS ON REQUIRED FINAL MASTERY.

C) DERIVE PERFORMANCE REQUIREMENTS FOR THE STATED PROGRAM CURRICULUM OBJECTIVE. THESE REPRESENT STATEMENTS OF ALL OPERATING LIMITATIONS, CONDITIONS OR GIVEN AFFECTING THE IMPLEMENTATION OR CONTENT OF THE PROGRAM CURRICULUM OBJECTIVE.

D) TRANSLATE ALL EXISTING COURSES PRESENTLY REQUIRED FOR GRADUATION FROM YOUR PROGRAM AREA INTO CURRICULUM OBJECTIVES (VOCATIONAL/OCCUPATIONAL COURSES ONLY).

E) DEFINE THE TERMINAL MASTERY (COGNITIVE/AFFECTIVE/PSYCHOMOTOR) WHICH STUDENTS MUST ACHIEVE FROM EACH NON-OCCUPATIONAL/VOCATIONAL COURSE INCLUDED IN YOUR PROGRAM.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

Job Entry Requirements
Electronics Technician

The duties of an Electronics Technician upon completion of the two-year program at Fresno City College are as follows:

Primary Function

Under close daily supervision, involving detailed and explicit instructions, performs and assists engineers or other personnel in routine technical work. Works from written and/or oral orders in one of the following fields: R & D or Process, Electronic Test, Computer Test, Service, Environmental Evaluation and Electronic Maintenance.

Principal Duties/Responsibilities*

1. R & D or Process Technician - Makes adjustments or changes in processes or processing equipment to produce microcircuits, thin films, piezo-electric, semiconductor and electronic devices of specific quality and yield. Performs routine repair, testing, and calibration work on established test set-ups. Builds simple fixtures (e.g., stacking fixtures for cylindrical grinding, evaporation masks), instruments, circuits or mechanical assemblies from detailed instructions.

2. Electronic Test Technician - Performs routine calibration, repair and troubleshooting work on instruments, systems and circuits. Records and maintains test data on instruments and electronic sub-assemblies. Makes adjustments or changes in processing equipment to produce microcircuits, thin films and semiconductor devices of specified quality and yield. Uses manufacturing and test documentation to build and test electronic circuits, sub-assemblies, microcircuits and/or semiconductor devices.

3. Computer Test Technician - Performs routine testing and troubleshooting of PC's from board to components; from instruments to sub-assembly; from system to instrument. Interfaces computers with peripherals (i.e., insert PC boards, attach cables and configure software).

4. Service Technician - Performs routine troubleshooting, preventive maintenance, adjustment and calibration work on a specified line of instruments. Records and maintains test data on parts and initiates replacement parts requests. Replaces modules or components as directed by supervisor. Refurbishes equipment (painting, cleaning, etc.) as required.

5. Electronic Maintenance Technician - Performs routine calibration, repair, and troubleshooting of various Company-owned instruments (manufactured by HP or other companies) as specified by the division's procedures and calibration programs. These products are normally those of minimum complexity. Records and maintains calibration data and initiates re-placement parts requests.

* Note - Duties listed are not all-inclusive but are intended to be indicative of the job.

6. Semiconductor Technician - Fabricates under direction silicon devices, silicon integrated circuits or devices in various III-V compound materials, working from run sheets and basic process specifications. Able to perform several of the following fabrication processes, i.e., epitaxy, diffusions, photoresist, cleaning, etching, and/or some of the following bonding assembly processes, i.e., ball bonding, ultrasonic bonding, lead bonding, die attach, package sealing, welding and soldering, etc. Ability to make minor process changes as instructed by the supervisor. Able to inspect own work as run is processed. Performs routine DC or RF electrical testings related to semiconductor fabrication. Prepares chemical mixtures and solutions following instructions from engineer.

7. TV Technician - Sets up, operates, and makes minor adjustments to video and audio equipment. Carries out routine preventive maintenance procedures. Assists in troubleshooting and repairing video and audio equipment. Performs TV production related tasks as assigned by supervisor.

Job Entry Requirements - What He Must Know:

1. How to fill out a job application.
2. How to perform in a job interview.
3. How to read technical manuals.
4. How to follow written instructions/engineering instructions.
5. How to follow oral instructions.
6. How to write out a work report.
7. How to write out a work order.
8. How to make out a bill, computing costs of materials, labor, and taxes.
9. How to perform the necessary tasks inherent to the technician's role.

Job Entry Requirements - What He Must Do:

1. Be able to use the various meters employed in testing.
2. Be able to use correctly the tools employed in the maintenance and repair of electronic devices.
3. Be able to observe the proper safety precautions in the use of the tools and equipment he will be working on.

Job Entry Requirements - What He Must Be (Behavioral and Attitudinal):

Research and Design Project, Electronics
Job Entry Requirements (Continued)

1. He must maintain an acceptable appearance.
2. He must be able to accept constructive criticism.
3. He must be able to get along with his fellow workers.
4. His work must be consistent with adequate quality standards.
5. He must be able to follow instructions.
6. He must show respect for equipment and other property.
7. He must be punctual.
8. He must be willing to work unusual schedules when required.
9. He must be willing to relocate according to the demands of the particular job or the job market in general.
10. He must be willing to continue to learn and keep abreast of the constantly changing field of electronics.

ON THE FOLLOWING PAGES, YOU ARE PROVIDED WITH AN ANALYSIS OF THE ENTRY-LEVEL SKILLS/KNOWLEDGES/ATTITUDES REQUIRED TO SUCCEED IN THIS OCCUPATIONAL AREA. THE INFORMATION IS TAKEN FROM THE DICTIONARY OF OCCUPATIONAL TITLES, D.O.T., COMPILED BY THE DEPARTMENT OF LABOR.

THIS ANALYSIS IS ONE OF SEVERAL SOURCES USED BY THE PROJECT DURING PHASE II TO DEFINE THE LEVELS AT WHICH A STUDENT WOULD HAVE TO BE ABLE TO PERFORM IN ORDER TO ENTER AND SUCCEED IN THIS PROGRAM. THESE LEVELS FURTHER SERVED TO HELP PUT LIMITS ON REMEDIAL PROGRAMS DESIGNED TO BRING A STUDENT UP TO ENTRY-LEVEL STANDARDS.

RESEARCH DESIGN PROJECT FOR DISADVANTAGED STUDENTS DOT INFORMATION SHEET

OCCUPATIONAL EDUCATION
NOV 15 1977

VOCATIONAL PROGRAM: ELECTRONICS

WORKER TRAIT NUMBER THIS VOCATIONAL CLUSTER: .281

JOBS WITHIN THIS VOCATIONAL CLUSTER:

Job	DOT Number
1. Electric Motor Analyst	721.281
2. Electrician Research	726.281
3. Electrical Equipment Tester	729.381
4. Audio-Video Repairman	729.281
5. Electric Motor Assembler	721.381

BREAK-DOWN OF VOCATIONAL CLUSTER WORKER TRAIT INFORMATION:

A. CLUSTER: ELECTRONICS

B. JOB:
1. Electric Motor Analyst — DOT NUMBER 721.281
2. Electrician Research — DOT NUMBER 726.281
3. Audio-Video Repairman — DOT NUMBER 729.281

C. WORKER TRAITS RELATED TO DATA, PEOPLE, THINGS:

A. Analyzing
B. No Significant Relationship
C. Precision Working

D. GENERAL EDUCATIONAL DEVELOPED REQUIRED:

1. Reasoning Development -- Level GED 3 & 4

Apply principles of rational systems[1] to solve practical problems and deal with a variety of concrete variables in situations where only limited standardization exists. Interpret a variety of instructions furnished in written, oral, diagrammatic, or schedule form.

Apply common sense understand to carry out instructions furnished in written oral, or diagrammatic form. Deal with problems involving several concrete variables in or from standardizaed situations.

D.GENERAL EDUCATIONAL DEVELOPMENT REQUIRED Con't.

2. Matematical Development, Level GED 3 & 4

Perform ordinary arithmetic, algebraic, and geometric procedures in standard, practical applications.

Make arithmetic calculations involving fractions, decimals and percentages.

3. Language Developmemt, Level GED 3 & 4

Comprehension and expression of a level to
- Transcribe dictation, make appointments for executive and handle his personal mail, interview and screen people wishing to speak to him, and write routine correspondence on own initiative.
- Interview job applicants to determine work best suited for their abilities and experience, and contact employers to interest them in services of agency.
- Interpret technical manuals as well as drawings and specifications such as layouts, blueprints, and schematics.

(Continued 2 b)

E. APTITUDES; Specific capabilities and abilities required in order to learn or perform adequately a job duty.

Aptitude	Level	Explanation
G	4	INTELLIGENCE: General learning ability. The ability to "catch on" or understand instructions and underlying principles. Ability to reason and make judgments. Closely related to doing well in school. (4) The lowest third exclusive of the bottom 10 percent of the population. This segment of the population possesses a below average or low degree of the aptitude.
V	4	VERBAL: Ability to understand meanings of words and ideas associated with them, and to use them effectively. To comprehend language, to understand relationships between words, and to understand meanings of whole sentences and paragraphs. To present information or ideas clearly.

Aptitude	Level	Explanation (Continued)
N	4	NUMERICAL: Ability to perform arithmetic operations quickly and accurately. (4) See previous page
S	4	SPATIAL: Ability to comprehend forms in space and understand relationships of plane and solid objects. May be used in such tasks as blueprint reading and in solving geometry problems. Frequently described as the ability to "visualize" objects of two or three dimensions, or to think visually of geometric forms. (4) See Previous page
P	4	FORM PERCEPTION: Ability to perceive pertinent detail in objects or in prictorial or graphic materials; To make visual comparisons and discriminations and see slight differences in shapes and shadings of figures and widths and lengths of lines. (4) See previous page
K	4	MOTOR COORDINATION: Ability to coordinate eyes and hands or fingers rapidly and accurately in making precise movements with speed. Ability to make a movement response accurately and quickly. (4) See Previous Page
F	4	FINGER DEXTERITY: Ability to move the fingers and manipulate small objects with the fingers rapidly or accurately. (4) See previous page
M	4	MANUAL DEXTERITY: Ability to move the hands easily and skillfully. To work with hands in placing and turing motions.

3. Language Development, Level GED 3 & 4 (Continued)

Comprehension and expression of a level to
- -File, post, and mail such material as forms, checks, receipts, and bills.
- -Copy data from one record to another, fill in report forms, and type all work from rough draft or corrected copy.
- -Interview members of household to obtain such information as age, occupation, and number of children, to be used as data for surveys, or economic studies.
- -Guide people on tours through historical or public buildings, describing such features as size, value, and points of interest.

E. SPECIFIC VOCATIONAL PREPARATION - Amount of time required to learn the techniques needed for average performance of job duties.

1. Over 1 year up to and including 2 years.

2. Over 2 years up to and including 4 years.

3. Over 4 years up to and including 10 years.

F. INTERESTS - Perferences for certain types of work activities or experiences.

1. Situations involving a preference for activities dealing with things and objects.

2. Situations involving a preference for activities that are nonsocial in nature, and are carried on in relation to processes, machines, and techniques.

3. Situations involving a preference for activities resulting in tangible, productive satisfaction.

G. TEMPERAMENTS - Work situation adjustments required.

1. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information against sensory or judgmental criteria.

2. Situations involving the evaluation (arriving at generalizations, judgments, or decisions) of information

H. PHYSICAL DEMANDS - Physical demand activities required to perform job tasks

L - Light Work - lifting 20 lbs. maximum with frequent lifting and/or carrying of objects weighing up to 10 lbs. Even though the weight lifted may be only a negligible amount, a job is in this category when it requires walking or standing to a significant degree, or when it involves sitting most of the time with a degree of pushing and pulling of arm and/or leg controls.

M-Medium Work: Lifting 50 lbs. maximum with frequent lifting and/or carrying of objects weighing up to 25 lbs.

H-Heavy Work: Lifting 100 lbs. maximum with frequent lifting and/or carrying of objects weighing up to 50 lbs.

Climbing and/or Balancing:
(1) Climbing: ascending or descending ladders, stairs, scaffolding, ramps, poles, ropes, and the like, using the feet and legs and/or hands and arms.

(2) Balancing: Maintaining body equilibrium to prevent falling when walking, standing, crouching, or running on narrow, slippery, or erratically moving surfaces; or maintaining body equilbrium when performing gymnastic feats.

H. PHYSICAL DEMANDS Con't.

STOOPING, KNEELING, CROUCHING, AND/OR CRAWLING:

(1) Stooping: Bending the body downward and forward by bending the spine at the waist.

(2) Kneeling: Bending the legs at the knees to come to rest on the knee or knees.

(3) Crouching: Bending the body downward and foward by bending the legs and spine.

(4) Crawling: Moving about on the hands and kness or hands and feet.

REACHING, HANDLING, FINGERING, AND/OR FEELING:

(1) Readhing: Extending the hands and arms in any direction.

(2) Handling: Seizing, holding, grasping, turning, or otherwise working with the hand or hands (fingering not involved).

(3) Fingering: Picking, pinching, or otherwise working with the fingers primarily (rather than with the whole hand or arm as in handling).

(4) Feeling: Perceiving such attributes of objects and materials as size, shape, temperature, or texture, by means of receptors in the skin, particularly those of the finger tips.

SEEING:

Obtaining impressions through the eyes of the shape, size, distance, motion, color, or other characteristics of objects. The major visual functions are: (1) acuity, far and near, (2) depth perception, (3) field of vision (4) accommodation (5) color vision. The functions are defined as follows:

(1) Acuity, far - clarity of vision at 20 feet or more.
Acuity, near - clarity of vision at 20 inches or less.

(2) Depth perception - three dimensional vision. he ability to judge distance and space relationships so as to see objects where and as they actually are.

(See Page 4 a)

I. WORKING CONDITIONS -- Physical surrondings of a worker in a specific job.

H. PHYSICAL DEMANDS (Continued)

(3) Field of vision - the area that can be seen up and down or to the right or left while the eyes are fixed on a given point.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

Program Curriculum Objective

Upon completion of the two-year certificate program or the completion of the A.S. degree requirements, the student will be prepared for employment as an electronics technician.

The student must achieve knowledge and skills in basic electronics (principles and applications). He/she must be able to analyze, design, construct and troubleshoot electronic circuits which are found in computers, microwaves, AM and FM broadcast equipment.

The student must be able to demonstrate knowledge by passing comprehensive examinations at the end of each unit with a minimum proficiency of 70%.

The student must be able to complete the required laboratory experiments* and projects** successfully and submit an acceptable technical report for each of these tasks. These reports must demonstrate the student's comprehension of the entire procedure to the designated standards (technical report form) and the satisfaction of the instructor.

Operational Definitions:

* Experiments - a designed procedure to demonstrate a phenomenon or concept.

**Project - the construction of a complete system of components which demonstrate the principles learned in the course.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

Performance Requirements

1. The program must provide the learner with mastery skills in the following areas:

   a. DC/AC electricity
   b. semiconductor devices
   c. pulse and logic circuits
   d. communications equipment

2. Each course in the program will provide for lecture and lab hours as described by the courses of study.

3. Curriculum program will provide necessary knowledge to obtain a license in entertainment electronics.

4. The program must be structured to allow the student to complete the curriculum in four regular semesters.

5. It is recommended that the student do all four semesters in an unbroken sequence since the rapid change in electronic technology requires continual updating of knowledge and skills.

6. In addition to the above requirements, the student will be required to satisfy the following requirements of the certificate program:

   a. Industrial ED 36, Safety
   b. Industrial ED 51, Industrial Science
   c. Industrial ED 11, Basic Electricity
   d. Industrial ED 15, General Metals
   e. Engineering Technology 15, Computer Language

7. In addition to requirements 1, 2, 3, 4, and 5, a student desiring an Associate of Arts Degree must satisfy the requirements for this degree as specified in the College Catalogue.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

ER, EL, RT 51
Course Objective

Upon completion of ER, EL, RT 51, the learner must demonstrate knowledge of his/her ability to design and construct circuits using the concepts listed below:

1. Ohm's Law, Kirchoff's Law for AC and DC
2. Series-Parallel Circuits
3. Meter, Motors, Generators, and Batteries
4. Magnetism and Magnetic units
5. Reactive Circuits and related math
6. Semiconductors

He must demonstrate his proficiency by a 70% score on written tests, and the circuits that he constructs must operate at a level of 100% effectiveness.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

Electronics 52-52L
Course Objective

Upon completion of Electronics 52-52L, the student will demonstrate knowledge of the following:

1. theory of semiconductors
2. design principles of semiconductor circuits
3. relationship between and function of transistor circuits

These three areas of knowledge include the following:

a. two layer diodes
b. four layer diodes
c. junction transistors
d. optoelectronic devices
e. unijunction transistors
f. field effect transistors
g. integrated circuits

The student will design, construct, and analyze a minimum of 25 circuits which work with 100% effectiveness, and in this process he/she will use all basic test equipment.

A written technical report which meets the laboratory report standards will be submitted to the instructor for grading. The instructor will use a grading system involving points as itemized on the report outline. A written test must be passed at 70% or better for each circuit.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

ER 53
Course Objective

Upon completion of ER 53, the learner will demonstrate knowledge of Logic Circuits, Latches, Clocks and Gate Interfacing, Counters, Shift Registers by designing and constructing these circuits and proving the performance of each to the learner's satisfaction. A written technical report which meets the laboratory report standards will be submitted to the instructor for grading. The instructor will use a grade system involving points as itemized on the report outline. All circuits will be 100% operative and a written test must be passed at 70% or better for each circuit.

RESEARCH AND DESIGN

PROJECT: MOBILITY

STEPS OF CURRICULUM ANALYSIS

STEP 2

HAVING DEFINED THE REQUIREMENTS OF THE EMPLOYER AND RESTATED THE COLLEGE'S PROGRAMS IN PERFORMANCE TERMS; THE TEAM NOW SEEKS TO IDENTIFY WHAT EACH STUDENT MUST BE ABLE TO KNOW/FEEL/DO IN ORDER TO ACHIEVE THOSE OBJECTIVES. EACH COURSE OBJECTIVE IS ANALYZED TO IDENTIFY THE COGNITIVE/AFFECTIVE/PSYCHOMOTOR MASTERY EACH STUDENT MUST DEMONSTRATE TO SUCCEED. THIS ANALYSIS WILL PROVIDE THE TEAM WITH A DETAILED ENOUGH DEFINITION OF WHAT IS REQUIRED OF EACH COURSE TO SPECIFICALLY PINPOINT WHERE THE PROBLEM AREAS REALLY ARE.

STEP 2:

A) PERFORM A COGNITIVE/AFFECTIVE/PSYCHOMOTOR ANALYSIS OF EACH STATED COURSE OBJECTIVE TO DERIVE ALL HIGHEST LEVELS OF MASTERY REQUIRED FOR SUCCESSFUL COMPLETION OF THE COURSE.

B) STATE THE CRITERIA OF MASTERY FOR EACH ITEM IDENTIFIED IN THE COGNITIVE/AFFECTIVE/PSYCHOMOTOR ANALYSIS. THESE STATEMENTS WOULD INCLUDE THE METHOD OF EVALUATION AND THE LEVEL OF PERFORMANCE REQUIRED OF THE STUDENT (HOW AND HOW WELL). THIS STATEMENT IS NOT THE EXACT TEST ITEM THAT THE STUDENT WOULD ENCOUNTER (CRITERION MEASURE).

C) ASSESS EACH COURSE TO CONFIRM THAT THE SEQUENCING OF THE ITEMS OF MASTERY IS CORRECT ACCORDING TO THE TAXONOMIES; AND THAT THE COMBINED COURSES WILL PRODUCE THE MASTERY DEMANDED BY THE EMPLOYMENT REQUIREMENTS AND THE PROGRAM CURRICULUM OBJECTIVE (VOCATIONAL/OCCUPATIONAL COURSES ONLY).

RESEARCH AND DESIGN PROJECT
ELECTRONICS

SCOPE OF WORK

SPECIAL NOTE: It was the concensus of the design team that the largest majority of problems encountered by electronics students occur as a direct result of their inability to master the concepts presented in Electronics 51 - Fundamentals of Electronics.

For this reason the team decided to focus all their attention on identifying and solving the problems in this one critical course. All team products from this point on, therefore, will be specific to Electronics 51 - Fundamentals of Electronics.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

ELECTRONICS 51: FUNDAMENTALS OF ELECTRONICS

Elements of Required Mastery

Cognitive:

a. Electricity
   1. Negative and positive polarities
   2. Electrons and Protons in the Atom
   3. Structure of the Atom
   4. The Coulomb Unit of Charge
   5. The Volt Unit of Potential Difference
   6. Charge in Motion is Current
   7. Resistance is Opposition to Current
   8. The Closed Circuit
   9. Direct Current (DC) and Alternating Current (AC)
   10. Sources of Electricity

b. Ohms Law
   1. The Current I = V/R
   2. The Voltage V = IR
   3. The Resistance R = V/I
   4. Practical Units
   5. Multiple and Submultiple Units
   6. The Linear Proportion between V and I
   7. Power
   8. Power Dissipation in Resistance
   9. Electric Shock

c. Series Circuits
   1. Why I is the same in All Parts of a Series Circuit
   2. Total R Equals the Sum of All Series Resistances
   3. Series IR Voltage Drops
   4. The Sum of Series IR Drops Equals the Applied Vt
   5. Polarity of IR Voltage Drops
   6. Polarities to Chasssis Ground
   7. Total Power in a Series Circuit
   8. Series-Aiding and Series-Opposing Voltages
   9. Analyzing Series Circuits
   10. Effect of an Open Circuit in a Series Path

d. Parallel Circuits
   1. The Applied Voltage Va is the Same across Parallel Branches
   2. Each Branch I Equals Va/R
   3. The Main-Line It Equals the Sum of the Branch Currents
   4. Resistances in Parallel
   5. Conductances in Parallel
   6. Total Power in Parallel Circuits
   7. Analyzing Parallel Circuits
   8. Effect of an Open Branch in Parallel Circuits
   9. Effect of a Short Circuit across Parallel Branches

e. Series-Parallel Circuits
   1. Finding Rt for Series-Parallel Resistances
   2. Resistance Strings in Parallel
   3. Resistance Banks in Series
   4. Resistance Banks and Strings in Series-Parallel
   5. Analyzing Series-Parallel Circuits
   6. Wheatstone Bridge
   7. Chassis-Ground Connects
   8. Voltages Measured to Chassis Ground
   9. Opens and Shorts in Series-Parallel Circuits

f. Voltage Dividers and Current Dividers
   1. Series Voltage Dividers
   2. Current Divider with Two Parallel Resistances
   3. Current Division by Parallel Conductances
   4. Series Voltage Divider with Parallel Load Current
   5. Design of a Loaded Voltage Divider

g. Direct-Current Meters
   1. Moving-Coil Meter
   2. Measurement of Current
   3. Meter Shunts
   4. The Ayrton or Universal Shunt
   5. Voltmeters
   6. Loading Effect of a Voltmeter
   7. Ohmmeters
   8. Multimeters
   9. Digital Meters
   10. Meter Applications
   11. Checking Continuity with the Ohmmeter

h. Kirchoff's Laws
   1. Kirchoff's Current Law
   2. Kirchoff's Voltage Law
   3. Method of Branch Currents
   4. Node-Voltage Analysis
   5. Method of Mesh Currents

i. Network Theorems
   1. Superposition
   2. Thevenin's Theorem
   3. Theveninizing a Circuit with Two Voltages Sources
   4. Theveninizing a Bridge Circuit
   5. Norton's Theorem
   6. Thevenin-Norton Conversions
   7. Conversion of Voltage and Current Sources
   8. Millman's Theorem
   9. T and π Networks

j. Conductors and Insulators
   1. Function of the Conductor
   2. Standard Wire Gage Sizes
   3. Types of Wire Conductors

4. Printed Wiring
5. Switches
6. Fuses
7. Pilot Lamps
8. Wire Resistance
9. Temperature Coefficient of Resistance
10. Ion Current in Liquids and Gases
11. Electrons and Hole Charges in Semiconductors
12. Insulators

k. Resistors
   1. Resistor Types
   2. Variable Resistors
   3. Potentiometers and Theostats
   4. Resistor Color Coding
   5. Power Rating of Resistors
   6. Choosing a Resistor for a Circuit
   7. Series and Parallel Combinations of Resistors
   8. Resistor Troubles

l. Batteries
   1. Functions of Batteries
   2. The Voltaic Cell
   3. Carbon-Zinc Dry Cell
   4. Series and Parallel Cells
   5. Lead-Acid Wet Cell
   6. Types of Electromotive Cells
   7. Internal Resistance of a Generator
   8. Matching a Load Resistance to the Generator

m. Magnetism
   1. The Magnetic Field
   2. Magnetic Flux Φ
   3. Flux Density B
   4. Induction by the Magnetic Field
   5. Air Gap of a Magnet
   6. Types of Magnets
   7. Ferrites
   8. Magnetic Shielding
   9. The Hall Effect

n. Magnetic Units
   1. Ampere-turns (NI)
   2. Field Intensity (H)
   3. Permeability (μ)
   4. B-H Magnetization Curve
   5. Magnetic Hysteresis
   6. Ohm's Law for Magnetic Circuits
   7. Relations between Magnetic Units
   8. Comparison of Magnetic and Electric Fields

o. Electromagnetic Induction
   1. Magnetic Field around an Electrical Current
   2. Magnetic Polarity of a Coil
   3. Motor Action between Two Magnetic Fields

4. Induced Current
5. Lenz' Law
6. Generating an Induced Voltage
7. Faraday's Law of Induced Voltage

p. Alternating Voltage and Current
1. Alternating-Voltage Generator
2. The Sine Wave
3. Alternating Current
4. Voltage and Current Valves for a Sine Wave
5. Frequency
6. Period
7. Wavelength
8. Phase Angle
9. The Time Factor in Frequency and Phase
10. AC Circuits with Resistance
11. Nonsinusoidal AC Waveforms
12. Harmonic Frequencies

q. The 60-H_z AC Power Line
1. Advantages of 120-V 60-H_z AC Power
2. Motors and Generators
3. Fluorescent Lighting
4. Residential Wiring
5. Three-Phase Power

r. Inductance
1. Induction by Alternating Current
2. Self-inductance
3. Self-induced Voltage v_L
4. How v_L Opposes a Change in Current
5. Mutual Inductance
6. Transformers
7. Core Losses
8. Types of Cores
9. Variable Inductance
10. Inductances in Series or Parallel
11. Stray Inductance
12. Energy in Magnetic Field of Inductance
13. Troubles in Coils

s. Inductive Reactance
1. How X_L Reduces the Amount of I
2. $X_L = 2\pi fL$
3. Series or Parallel Inductive Reactances
4. Ohm's Law Applied to X_L
5. Applications of X_L for Different Frequencies
6. Waveshape of v_L Induced by Sine-Wave Current

t. Inductive Circuits
1. Sine-Wave i_L Lags v_L by 90°
2. X_L and R in Series

3. Impedance (Z)
4. X_L and R in Parallel
5. Q of a Coil
6. AF and RF Chokes
7. The General Case of Inductive Voltage
8. Calculating the L/R Time Constant

u. Capacitance
1. How Charge Is Stored in the Dielectric
2. Charging and Discharging a Capacitor
3. The Farad Unit of Capacitance
4. Typical Capacitors
5. Capacitor Color Coding
6. Parallel Capacitances
7. Series Capacitances
8. Stray Capacitive and Inductive Effects
9. Energy in Electrostatic Field of Capacitance
10. Troubles in Capacitors

v. Capacitive Reactance
1. Alternating Current in a Capacitive Circuit
2. $X_C = 1/(2\pi fC)$
3. Series or Parallel Capacitive Reactances
4. Ohm's Law Applied to X_C
5. Applications of Capacitive Reactance
6. Sine Wave Charge and Discharge Current

w. Capacitive Circuits
1. Sine-Wave v_C Lags i_C by 90°
2. X_C and R in Series
3. X_C and R in Parallel
4. RF and AF Coupling Capacitors
5. Capacitive Voltage Dividers
6. The General Case of Capacitive Current i_C
7. Calculating the RC Time Constant

x. RC and 1/R Time Constants
1. Response of Resistance Alone
2. L/R Time Constant
3. High Voltage Produced by Opening RL Circuit
4. RC Time Constant
5. RC Charge and Discharge Curves
6. High Current Produced by Short-circuiting RC Circuit
7. RC Waveshapes
8. Long and Short Time Constants
9. Charge and Discharge with Short RC Time Constant
10. Long Time Constant for RC Coupling Circuit
11. Universal Time Constant Graph
12. Comparison of Reactance and Time Constant

y. Alternating-Current Circuits
1. AC Circuits with Resistance but No Reactance

2. Circuits with X_L Alone
3. Circuits with X_C Alone
4. Opposite Reactances Cancel
5. Series Reactance and Resistance
6. Parallel Reactance and Resistance
7. Series-Parallel Reactance and Resistance
8. Real Power
9. AC Meters
10. Wattmeters
11. Summary of Types of Ohms in AC Circuits
12. Summary of Types of Phasors in AC Circuits

z. Complex Numbers for AC Circuits
1. Positive and Negative Numbers
2. The i Operator
3. Definition of a Complex Number
4. How Complex Numbers Are Applied to AC Circuits
5. Impedance in Complex Form
6. Operations with Complex Numbers
7. Magnitude and Angle of a Complex Number
8. Polar Form of Complex Numbers
9. Converting Polar to Rectangular Form
10. Complex Numbers in Series AC Circuits
11. Complex Numbers in Parallel AC Circuits
12. Combining Two Complex Branch Impedances
13. Combining Comples Branch Currents
14. Parallel Circuit with Three Complex Branches

aa. Resonance
1. The Resonance Effect
2. Series Resonance
3. Parallel Resonance
4. The Resonant Frequency $f_r = 1/(2\pi\sqrt{LC})$
5. Q Magnification Factor of Resonant Circuit
6. Bandwidth of Resonant Circuit
7. Tuning
8. Mistuning
9. Analysis of Parallel Resonant Circuits
10. Damping of Parallel Resonant Circuits
11. Choosing L and C for a Resonant Circuit

bb. Filters
1. Examples of Filtering
2. Direct Current Combined with Alternating Current
3. Transformer Coupling
4. Capacitive Coupling
5. Bypass Capacitors
6. Filter Circuits
7. Low-pass Filters
8. High-pass Filters
9. Resonant Filters
10. Interference Filters

cc. Vacuum Tubes
1. Rectifiers, Amplifiers, and Oscillators
2. Construction of Tubes
3. Diodes
4. Plate Current
5. Diode Rectifier Circuit
6. Triodes
7. How a Triode Amplifies the Control-Grid Voltage
8. Triode Characteristics
9. Tube Parameters
10. Tetrodes
11. Pentodes
12. Tube Types
13. The Cathode-Ray Tube (CRT)
14. Troubles in Vacuum Tubes

dd. Semiconductor Diodes and Transistors
1. Types of Semiconductor Devices
2. Characteristics Semiconductors
3. N-type and P-type Doping
4. Current in Semiconductors
5. The PN Junction
6. Diode Rectifier Circuits
7. Transistors
8. Transistor Amplifier Circuits
9. The CE Amplifier Circuit
10. Collector Characteristic Curves
11. Load-Line Analysis
12. Bias Stabilization
13. Field-Effect Transistor (FET)
14. Silicon Controlled Rectifier (SCR)
15. Types of Transistors
16. Special-Purpose Diodes
17. Transistor Troubles

RESEARCH AND DESIGN

PROJECT: MOBILITY

STEPS OF CURRICULUM ANALYSIS

STEP 3

USING THEIR COMPLETED COGNITIVE/AFFECTIVE/PSYCHOMOTOR ANALYSIS AND CHARACTERISTICS OF THE TARGET STUDENTS FROM THE NEED ASSESSMENT AND THEIR PAST EXPERIENCE, THE TEAM ASSESSES EACH ELEMENT OF REQUIRED MASTERY TO IDENTIFY WHERE THE STUDENTS ARE ENCOUNTERING PROBLEMS. THEY ALSO IDENTIFY NON-CONTENT RELATED PROBLEM AREAS.

HAVING PINPOINTED AN AREA, IT IS FURTHER ANALYZED TO IDENTIFY WHAT FACTORS ARE CONTRIBUTING TO THE CREATION OF THE PROBLEM. THESE WILL BE THE PROBLEMS THAT THE TEAM WILL FOCUS THE REST OF THEIR EFFORTS ON SOLVING.

STEP 3:

DETAILED INSTRUCTIONS PROVIDED TO THE TEAM FOR STEP 3.

A) IDENTIFY THOSE ITEMS OF MASTERY REQUIRED IN EACH COURSE WHICH REPRESENT PROBLEM AREAS FOR THE DISADVANTAGED STUDENT; I.E., REQUIRED PROFICIENCY LEVELS NOT BEING ATTAINED.

B) DIAGNOSE/IDENTIFY THE NATURE OF THE PROBLEM AREAS AND THEIR PERCEIVED CAUSES FOR PERFORMANCE DEFICIENCIES IN TERMS OF 1) STUDENT RELATED AND 2) CURRICULUM/COURSE RELATED CAUSES.

C) PRIORITIZE THE IDENTIFIED PROBLEM AREAS ACCORDING TO THEIR CRITICALITY FOR CONTINUING SUCCESS BY THE DISADVANTAGED STUDENT.

P.O. BOX 5089, ANAHEIM, CALIFORNIA 92804 - (714) 539-4359

RESEARCH AND DESIGN PROJECT

Identification of Problem Areas

Instructions For The Completion of Overall Step 3

Operational Definition

Problem Area for the Disadvantaged Student: those areas in the curriculum which consistently present problems to disadvantaged students as a group, rather than to a single individual, which cause any of the following:

a. failure to achieve required mastery proficiency for course/curriculum

b. difficulty in achieving one or more mastery skills or a continuum of skills in a course

c. inability to complete course or curriculum (drops out)

d. the requirement for instructional support beyond that normally provided for students.

Steps To Be Performed

1. Compare course mastery skills with Job Entry requirements in Cognitive/Psychomotor/Affective domains.

   List job entry requirements not presently taught in courses.

2. Assess each mastery item stated for the course and identify any mastery skill within which disadvantaged students encounter academic or content problems in the three domains, per the operational definition, and personal experience.

   Note: If disadvantaged students drop out of curriculum during or following the basic course, and heretofore have not enrolled in higher courses, in analyzing the higher level courses, identify those areas which do present problems to normal students. Rationale: If normal students have problem areas, it can be anticipated that disadvantaged student who remain in the program will encounter similar or worse problems.

   Divide a page into three columns. In the left column, list the identified problem areas in mastery skills.

3. Diagnose/Identify the nature of the problem areas and their perceived causes in terms of critical incidents, personal experience or existing data as related to student related causes or instructional/learning related problems. (See the following for examples.)

   a. Student related causes: List these in center column of page next to mastery problem identified in left column.

Examples:

1. Lack of prerequisite skills required of the mastery skill. (Specify exact skills.)

2. Inability to cope with the reading requirements. (Specify student level of reading, or required level.)

3. Personality or emotional factors. (Cite as related to curriculum, or specific incidents.)

4. Cultural differences. (Cite as related to curriculum or skill mastery.)

5. Cannot transfer knowledge learned in "lecture" to application/psychomotor. (Specify exact nature of failure.)

6. Cannot master cognitive criteria but learns in the lab with oral instructions.

7. Cannot relate "lab" experiences to classroom theory or principles.

8. Any others you might cite.

b. Instructional related causes: List these in the right column opposite mastery problem.

Examples:

1. Learning steps too large for student.

2. Materials (quantity or level) used are beyond abilities of students.

3. Methods of instruction do not match learning styles of students.

4. Failure to build continuum of levels according to taxonomies, i.e., jumping from recall to application, or requiring students to analyze without lead-up learning in comprehension and transfer to application, etc.

5. lack of facilities/equipment.

6. no special services to be responsive to specific needs of group of learners or individuals.

7. any others you might identify.

4. Identify any additional problem areas you know to exist which are not tied directly to an academic mastery skill, i.e., sociological, cultural, emotional, etc.

   These might act as cues which will lead to the identification of areas in the curriculum requiring modification or expansion, or to services which can be provided such learners through counseling/ guidance, etc.

   List problem areas in this category.

5. Prioritize problem areas: The points of reference for this step are the three lists that you have produced

   --Job Entry Requirements not presently taught in courses
   --Academic or content problem areas for mastery in courses
   --Additional problem areas in non-academic category

   a. As a first step, inspect each item on each list and, through concurrence by committee members, determine whether the item would be grouped under the following categories:

      1. Problems which can be handled within the instructional program for which you are responsible

      2. Problems which are academically oriented, but not part of your normal courses, but related to other disciplines

      3. Problem areas for which special services might be provided outside of the instructional program.

      As you are performing this analysis, start a separate list of problem areas recommended for handling by other disciplines of instruction or for special services.

   b. For those problem areas which are within your instructional programs or mastery skills in the courses, reach concurrence by committee members as to the priority order in which problem areas should be solved, considering the following factors:

      1. Criticality of the problem mastery skills to continuing or following skills in the course

      2. How failure to master a particular skill contributes to overall achievement of course objective and criteria

      3. Criticality of mastery of cognitive content before transfer to application or psychomotor

4. How mastery of problem areas in the basic course carries over to higher level courses (i.e., will achievement in the basic course reduce problems identified in following courses, or are problems in higher courses related to the specific content in those courses?)

5. Importance of success in mastery of cognitive and psychomotor skills in reducing problem areas in the affective domain

On the list of problem areas for mastery in courses, number the items in priority order.

IDENTIFICATION OF PROBLEM AREAS AND SOURCES OF PROBLEMS

Problem Areas for Students	Sources of Problems		
	Student Related Causes	Instructionally Related Causes	Sociological/Cultural Causes

RESEARCH AND DESIGN PROJECT
ELECTRONICS

Major General Problems	Student Related Causes	Instructional Learning Causes	Sociological/Cultural Causes
Problem Area for Student			
Job Entry Discrepancies:			
1. Learn process verbally but do not practice. 2. Troubleshooting weak (cannot duplicate all equipment). 3. Learn processes (knowledge but do not practice); not feasible because of equipment required.	1. Inability to read/comprehend. 2. Inability to perform simple arithmetic through fraction, decimal. 3. Inability to visualize abstract: ex., electrons flowing; doing work (functions of what goes on in circuit). 4. Inability to write up experiments, terminology, sentences, explanation. 5. Inability to transfer from schematic to actual unit. 6. Identification of symbols which identify parts (first unit). 7. Organizing themselves in orderly manner to do work, homework, solve problems.	1. Suggestion: What is electronics? First day - film.	1. Control notes--finding that they are on their own.
Affective:			
Some taken care of in courses, but will be analyzed again from viewpoint of disadvantaged learner.			

RESEARCH AND DESIGN PROJECT
ELECTRONICS

EL 51

Problem Area for Student	Student Related Causes	Instructional Learning Causes	Sociological/Cultural Causes
* A. Electricity			
1. Visualization of atomic structure.	1. Inability to visualize what cannot be seen; imagination; conceptualization.	1. Time required to set up demonstration vs. time of instruction makes the use of demonstrations limited.	
2. Terminology	2. Reading (phonics); pronunciation; meaning (concept).	2. Student is not checked out on terminology to make sure that he/she pronounces the word. Teacher assumes student "knows" the word when he has seen it and heard it.	
B. Ohm's Law			
1. Move from electricity's theory (a) to quantitative representations.	1. Student incurs problems in basic math.		
2. Manipulation of formula V = IR.	2. Student can't work a simple equation to solve for one unknown.		
3. Units - Practical - Amp, Volt, Ohm	3. Students don't understand these terms (vocabulary).		
4. Sub-multiple units, i.e., units less than 1 (milliampere, micropico^{-9}, nano^{-12}.	4. Students can't conceptualize extremely small numbers. Students have not had experience with exponents.		
5. Students cannot solve problems with calculators.	5. Students don't know how to use a calculator.	5. Students have different kinds of calculators.	5. Students cannot afford more expensive calculators or can't provide

* Note: The letter designations correlate to the Outline of Mastery. Only those areas representing a problem were included in this analysis. Those included were given the letter designation that corresponds to the Outline of Mastery.

Problem Area for Student	Student Related Causes	Instructional Learning Causes	Sociological/Cultural Causes
			good batteries. Students are reluctant to use simple decimal place counting with fingers. They think it is childish.
6. Vocabulary (See A #2)			
C. Series Circuit			
1. Understanding of relationships between voltage, resistance, current (voltage drops).	1. Students can't see relationships. Students lack fundamental physical concepts.		1. Limited background (experience) makes instructional analogies useless.
2. Polarity: + and - (positive and negative); something is positive only in the sense that something is negative to it.			
3. Schematic diagrams - symbols.	3. Cannot recognize various sections of a complete schematic. Students have problems reading text, schematic examples.		
E. Series - Parallel			
1. Trouble with manipulation of reciprocals and parallel formula.	1. Cannot manipulate or comprehend reciprocals.		
2. Problem visualizing parallel circuits when mixed in with series circuits.	2. Cannot separate series from parallel.		

Research and Design Project, Electronics (EL 51)
Identification of Problem Areas and Sources of Problems (Continued)

Problem Area for Student	Student Related Causes	Instructional Related Causes	Sociological/Cultural Causes
3. Voltage drops from series along with concepts of parallel current dividing.			3. Inability to visualize two or more variables.
I. 1. Superposition - requires a large number of simple steps but requires organized itemized recording to obtain solution.	1. Inability to keep adequate records of problem solution. Algebraic addition? + and - =. Volume of bookkeeping requires a high degree of organization. See attached example.	1. Instructor does not have time to work individually with students. Instructor is forced to teach the simplest way which is not the best, most efficient way. Student's math limitations force instructor to avoid higher math procedure.	
9. T and π network T = y π = Δ Conversion is not troublesome. Conversion leading to series parallel.	9. Weakness in handling series parallel; see E above.		
J. Conductors and Insulators			
1., 2., 3. Terminology (Bigger the number, the smaller the wire).	1., 2., 3. Vocabulary acquisition. Dealing with numbers relationships (bigger/smaller).		
8., 9. Wire resistance - Ohm's Law again. Resistances are so small. New concept - resistance in wire.	8., 9. Understanding new concepts.		
K. Resistors			
3. Patentiometer and Rheostats - new terminology; idea of variable resistance.			

Research and Design Project, Electronics (EL 51)
Identification of Problem Areas and Sources of Problems (Continued)

Problem Area for Student	Student Related Causes	Instructional Related Causes	Sociological/Cultural Causes
7. Reciprocal formula a) $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$ Only for two resistors. b) $R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$ For more than two resistors.	7. Students have never seen this kinds of an equation - stacked fraction. They don't relate the 1 to one volt.		7. Students are frightened by new things. They don't ask questions to clarify.
L. Batteries 7. "Internal Resistance of the Generator" - Students get it when presented, but do not recall it when it comes up later on. They understand theory but do not apply knowledge in lab.	7. Inability to recognize the problem when it occurs in lab.	7. Not enough application practice. Application is not a regular factor.	
8. Matching a Load Resistance to the Generator.	8. See #7.	8. See #7.	
M. and N. Magnetism Students need theory but not all specifics. Terminology: hysteresis, permeability, magnetic induction, density, ferrite.	Vocabulary skills.		
O. Electromagnetic Induction 1., 2., 4., 5. are the main points and 4 is the most important (induced current).			

Research and Design Project, Electronics (EL 51)
Identification of Problem Areas and Sources of Problems (Continued)

Problem Area for Student	Student Related Causes	Instructional/Learning Related Causes	Sociological/Cultural Causes
P. Alternating Voltage on Current (Very important section)			
1. Terminology.	Too much to control at one time: conceptual overload. Students have difficulty switching from the constancy of earlier information to the extensive variability. All this seems to contradict all they have learned to this point. This is the point where a lot of marginal students drop by the wayside.		
2. Positive and negative voltages.			
3. Frequency and time concept.			
4. Sine wave - pos and negative voltages; nothing is stationary, e.g., peak, peak to peak, RMS, average (constant--rate of change--second derivative).			
5. New concepts coalesce at this point:	Terminology Concepts	A lot of information to absorb. This is difficult for even the best students.	Student needs to have confidence so that he can endure this period of confusion.
a. Alternating--constant change	Inability to conceptualize very high numbers and very minute numbers, kilos, micro, etc.		
b. Sine Wave - a smattering of trigonometry			
c. Alternating			
d. Frequency/Period (Reciprocals)			
e. Time factor			
Q. Informational--Need only familiarity			

Research and Design Project, Electronics (EL 51)
Identification of Problem Areas and Sources of Problems (Continued)

Problem Area for Student	Student Related Causes	Instructional/Learning Related Causes	Sociological/Cultural Causes
R. Inductance			
4. Opposing voltage (back EMF) Double variables	4. Physics--concept.	4. Instruction presupposes student's ability to comprehend principles of physics.	
5. Mutual Inductance: Okay if they have understood previous instruction on inductance.			
6. Transformers			
7. Core Losses Hysterisis	Students have trouble with the textbook.		
T. 2. X_L and R in Series	Requires another step higher in math requirements.		
3. Impedance (Ż)			
4. X_L and R in parallel			
X.	11. Interpreting graphs is a problem and is not self evident.	11. Instructor may assume graphic techniques are understood.	
Y. AC Circuits	Culmination of many previous chapters, all applying at once, sometimes boggles the student's mind.	Simplicity of explanation in a step-by-step manner is required.	
Z. Complex Numbers for AC Circuits The j factor--deals with the time difference between voltage and current in AC circuits.	The problems are minimal for the student who has reached this point in the course.		

Research and Design Project, Electronics (EL 51)
Identification of Problem Areas and Sources of Problems (Continued)

Problem Area for Student	Student Related Causes	Instructional/Learning Related Causes	Sociological/Cultural Causes
aa. Resonance Principles of statistics, e.g., standard deviations, bell shaped curve, etc. Student is merely introduced to these things; they really don't come into play until the advanced courses.			
bb. Filters (See under aa.)			
cc. Vacuum tubes One day; of historical interest only.			

RESEARCH AND DESIGN

PROJECT: MOBILITY

STEPS OF CURRICULUM ANALYSIS

STEP 4

NOW THAT THE TEAM HAS PINPOINTED EXACTLY WHERE THE TARGET STUDENTS ARE ENOUNTERING PROBLEMS AND THE FACTORS CREATING THE PROBLEMS, THEY WILL TURN THEIR ATTENTION TO SOLVING THOSE PROBLEMS.

SOLVING THE PROBLEMS WILL INVOLVE THE SELECTION OR DEVELOPMENT OF NEW METHODS AND MEDIA OF INSTRUCTION, NEW PROGRAMS AND NEW SERVICES, ALL TAILORED TO THE UNIQUE NEEDS OF THE TARGET LEARNERS. BEFORE THE TEAM CAN MAKE THESE KINDS OF DECISIONS, HOWEVER, THEY MUST MORE SPECIFICALLY DEFINE THE EXACT NATURE OF THE MASTERY REQUIRED AND THE CRITERION OF MASTERY FOR EACH OF THE CONTENT PROBLEM AREAS. THIS WILL GIVE THEM ALL THE DATA THEY REQUIRE TO BE SURE THE CHANGES THEY RECOMMEND WILL BOTH GIVE EACH STUDENT THE SKILLS/KNOWLEDGES/ATTITUDES REQUIRED FOR EMPLOYMENT AND BE RESPONSIVE TO THE LEARNERS' NEEDS. THE METHODS/MEDIA RECOMMENDATIONS IDENTIFIED AT THIS STEP WILL BE COMBINED WITH THE RECOMMENDATIONS THAT WILL COME FROM STEP 5. IN COMBINATION THEY WILL CONSTITUTE THE TEAM'S SOLUTIONS TO THE PROBLEMS IDENTIFIED.

STEP 4:

DETAILED INSTRUCTIONS PROVIDED TO THE TEAM FOR STEP 4.

A) RESTATE THE PRIORITY PROBLEM AREAS AS TERMINAL PERFORMANCE OBJECTIVES.

B) DERIVE CRITERION MEASURES FOR EACH TERMINAL PERFORMANCE OBJECTIVE.

C) ANALYZE THE LEARNING REQUIREMENTS TO ACHIEVE EACH OBJECTIVE.

D) ORGANIZE THE LEARNING STEPS.

E) ANALYZE ALTERNATIVE METHODS AND MEDIA.

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RESEARCH AND DESIGN PROJECT

Development of Mastery Skills Identified as Priority Problem Areas

Instructions For The Completion of Overall Step 4

As a result of the identification of problem areas for disadvantaged learners in the mastery skills for each course, the faculty analysts will have made decisions as to the following:

1. Those problems which can be handled within the instructional/learning environment of the special areas' curriculum;
2. Those problems which should be handled either by
   a. other subject matter specialists (example, reading, math, others)
   b. special support services (example, counseling, guidance, psychological, placement, etc.).

Priorities for development will have been established also.

The procedures listed below are those which will be performed by the faculty to develop learning sequences and solutions for learning problems which can be handled in the instructional/learning environment (#1 above). Other problems will be referred to appropriate groups.

Throughout the procedure, itemized below, references will be made to portions of the SAFE manual, Designing For Predictable Learner Success--the manual used in the training sessions. The faculty analyst might reread the referenced sections for explanation, examples, processes and forms.

SUGGESTION: A more productive and efficient use of the faculty time might result in assigning each member of the team a different problem mastery skill for development, applying the following steps. Group concurrence might be reached in the individual products, periodically. In this manner several products might be developed in the time that it would take the group to produce one.

STEP 1. Restate the Problem Mastery Skill as a Terminal Performance Objective.

Reference: SAFE manual, pages 161-178, "Deriving and Stating Terminal Performance Objectives (T.P.O's)." Also see pages 61-78, "Criteria for the Writing and Critique of Performance Objectives."

Refer to the statements in the course mastery analysis (cognitive/psychomotor/affective). Add the elements to this statement which will expand it into a well stated learning objective, as specified in SAFE manual.

Refer also to the criterion measures identified in the mastery analysis for the evaluation portion of the objective.

Write objective in left column of Form I-2.

STEP 2. Derive Terminal Performance Criterion Measures.

Reference: SAFE manual, pages 179-199.

If you did not state criterion measures during mastery skill analysis, develop them now from the Terminal Performance Objective.

Some groups already performed this step when identifying the criterion measures in the course mastery skill analysis (criterion levels and specific test items).

However, since you have performed further analysis of the mastery skills during problem identification, you might have generated further data or gained other insights regarding learning proficiency. It is suggested, therefore, that you review the prestated criteria to determine the following:

a. Whether the level of proficiency is still acceptable or should be increased or decreased;
b. Whether the criterion measures or test items are valid measurement of achievement of the objective to indicate mastery;
c. Whether the present method of evaluation is still suitable or whether alternate methods of evaluation with the disadvantaged population might yield the data required for evaluation;
d. Whether additional items must be added or existing items deleted or changed so that the evaluation instrument or activity measures all aspects of mastery.

Your expertise and your problem identification analysis statements will be the basis for these judgments.

If changes are required, make them at this point.

In the second column of Form I-2, "Criterion Statement," list the conditions of evaluation.

In the third column of Form I-2, write in the items and instructions given to the student in the testing condition.

a. If questions on a final exam are used for evaluation, include only those items which measure this objective.
b. If a unit test is to be used, the test might be stapled to the form.

c. If evaluation is performance of psychomotor skills or activities, list the instructions given the student.

STEP 3. Analysis of Learning Requirements to Achieve Objectives.

Reference: SAFE manual, pages 201-219, Taxonomies Handout, and pages 145-146.

Using Form J-2, analyse the lead-up content (cognitive), skills (psychomotor), behavior (affective) required for achievement of the T.P.O.

Those groups who used course content outlines for identifying mastery skills will have a start on this step. The subtopics on the outlines might represent lead-up knowledge/skills. However, you might determine whether these should be expanded to give you all the required data for learning related to the T.P.O.

In doing this analysis, the reference is the disadvantaged learner.

1. Identify first what level in the taxonomy represents mastery.
2. Analyse from the learner's entry level* and from what the learner needs to know and do to build all elements of mastery.

*Entry level refers to what they have mastered from previous learning sequences or courses.

3. Refer to the taxonomies to determine what lead-up activities and levels the learner must achieve on a continuum from simple to complex.

Remember--do not leave out learning levels.

--they must learn and practice the mastery level before evaluation; i.e., if they must analyse, do not expect to give learning experience in recall, comprehension, and application and then expect them to analyse. They must also have learning experience in analysing or must learn how to analyse.

The columns on Form J-2 will give you cues.

STEP 4. Organize Learning Steps/Sequence.

Reference: SAFE manual, pages 277-299.

a. Using Form K-2, organize the learning requirements from the Cognitive/Psychomotor/Affective Analysis (Form J-2, 3) into the actual learning step sequence the learner will perform to achieve the objective.

Note: This might be in the order you stated in the analysis or you might want to schedule several recall activities or comprehension activities before application (for example).

Enter sequence in the left column of Form K-2.

b. As you are sequencing the learning steps, determine the response desired from the learner and whether this will be evaluated. Enter these in the second column of Form K-2.

STEP 5. *Method/Media Analysis.*

Reference: SAFE manual, papes 305-329.

a. Using the Decision-Making Model on page 312, SAFE manual, perform a method/media analysis on each learning step or a sequence of learning steps to determine the requirements based on the nature of the learning activities. This analysis can be performed quickly once you practice using the Decision-Making Model.

b. In Column 3, Form K-2, list the methods/media alternatives which can be used for the learning step or a sequence of steps. The alternatives might be those which you know about now. You might also wish to investigate others which are available in the Media Center or which are commercially available--both of which can be screened to determine if they meet the requirements for your population. Another possibility is that the Media Center might develop something, if nothing exists to meet your requirements.

In the last column, indicate your recommended selection, or final selection can be made during the management planning step.

Curriculum _____

Course/Unit Title _____

ACTUAL SIZE 8½" X 14"

TERMINAL LEARNING REQUIREMENTS

FORM I-2

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No.	No.	No.

ACTUAL SIZE 8½" X 14"

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: _____

T.P.O # _____

Level of Mastery: _____

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)

ACTUAL SIZE 8½" X 14"

FORM K-2

LEARNING SEQUENCE

Course/Unit: _____

T.P.O. # _____

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION

FORM I-2

Curriculum Electronic

Course/Unit Title ER 51, RT 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. a-1 Electricity The student will be able to visualize atomic structure and the relationship of the proton and electron and nucleus. a-2 To understand the basic units of measure of electricity, charge, potential difference, current, and resistance and their corresponding symbol.	No. a-1 Electricity By drawing a model of an atomic pattern showing the basic orbits of electrons around the nucleus of the atom. a-2 By writing the definitions of the basic units of charge, potential difference, amps and by identifying their respective symbols.	No. a-1 Electricity Draw and label the model of an atom and all parts including the electrons, protons. a-2 Write the definition of each unit listed and its associated symbol: 1. charge 2. potential difference 3. amps 4. resistance

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: ER 51

T.P.O # a. Electricity

Level of Mastery: Application

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1. Charge, Electron = (-), Proton (+) - Relative Mass	1. Explain the Electron, Proton & Nucleus & Their Relationship to One Another	Draw--See TPO (a)			
2. Electron Orbits Proton and Nucleus	2. Charge				
3. Electron is Actual Mover of Energy	3. Movement Relationship				
	4. Mass				
a.2 Recall the Key Points of: 1. Charge (Coulomes 6.25×10^{18} Electron 2. 2 Charges, Difference of Charge, Polarity 3. Current Movement of Charges 4. Resistance, Opposition to Movement of Charges. 5. C.V.I.R.	a.2 Explain the Definition of Charge, Pot Diff., I., R.				

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FORM K-2

LEARNING SEQUENCE

Course/Unit: ER 51

T.P.O. # a. Electricity

Proper Sequence From J-2

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Arrange in Proper Sequence a.2 Already in Proper Sequence	TPO (a) Recall From I-2	1. Video tapes either existing or created for showing atomic structure and/or current flow and basic electricity. 2. Possible atomic model of atoms built with showing valence electrons and bonding with adjacent atoms. 3. A Lab Assistant (qualified) to assist the instructor in the lab, especially when students are new and lab is crowded. He could be used to set up demonstrations for the instructor prior to lecture. He also could tutor and help the disadvantaged students in their efforts.	A video cassette recorder and player that must be broadcast compatible (NTSC Standards). 1. The reasons for the above requirement is the vast library of commercially available programs, tapes, etc. 2. It makes locally available commercial TV production facilities a possible resource. 3. It makes school produced material compatible with local TV equipment for possible airing on TV.

Curriculum Electronics

Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

FORM I-2

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. b.1 OHMS LAW Student will be able to solve common electrical problems using OHMS Law to find current (I), Voltage (V), Resistance (R).	No. b.1 Student will take two given values and solve for the unknown value of V, I or R using the proper OHMS Law formula. (70% correct or better is passing.)	No. b.1 Example (varied to represent different situations): Given the following values, V = ____, I = _____, then R = _____?

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

Course/Unit: Electronics

T.P.O # b.1

Level of Mastery: Synthesis

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
Have to remember what V, I and R mean in the circuit. Have to recall the basic OHMS Law formula. Have to remember the method of manipulating the formula to solve for various unknowns.	Explain the inter-relationship of V, I, and R.	Calculating and comparing answer to measured problem in lab situation.	Identify the unknown to be found. Identify the known quantities. Manipulate the formula to find solution.		

FORM K-2

Course/Unit: Electronics

T.P.O. # b.1

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
b.1 Already in proper sequence.	TPO b.1 Recall from I-2.	Set up a remedial math (arithmetic) and basic equation manipulation, algebra, fractions, decimals. See General Recommendations. A method of helping disadvantaged students to visualize the electrical terms with substitute mind pictures based upon their experiences. Someone must take key terms (electrical) and find alternate meaningful descriptions (to student) befitting his social and cultural background.	

FORM I-2

Curriculum Electronics

Course/Unit Title ER-51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. b-2 To be able to derive the various configurations of Ohm's basic law to solve for the solution of V, I, or R. 1) $V = I R$ 2) $I = \frac{V}{R}$ 3) $R = \frac{V}{I}$	No. The student will take the basic form of Ohm's Law, V = I x R, and algebraically rearrange it to solve for I or R also. (70% accuracy)	No. Write the equation of Ohm's Law needed to solve for: 1) V = _____ 2) I = _____ 3) R = _____

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics

T.P.O # B-2

Level of Mastery: Application

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1) Meaning of V, I, and R. 2) Relationship of a) V to R and I b) I to R and V c) R to V and I 3) Rules of operations for equations a) multiply equation b) divide equation c) equality of equation	Explain the alegrat steps necessary to rearrange the basic formula, V = I x R.	Write equations to solve for V, I and R: 1) $V = I \times R$ 2) $I = \frac{V}{R}$ 3) $R = \frac{V}{I}$			

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FORM K-2

LEARNING SEQUENCE

Course/Unit: Electronics

T.P.O. # B-2

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	See Recommendations for B.1, Ohm's Law	

FORM I-2

Curriculum Electronics

Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. b.3 The student comprehends the relationship of volts (V), amps (A) and Ohms (Ω).	No. b.3 By relating volts to pressure and amps to flow of current through resistance in Ohms as a result of the pressure in volts.	No. b.3 Determine whether current flow in amps will increase or decrease if the voltage is constant and the resistance in Ohms is decreased in a circuit.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics

T.P.O # b. 3

Level of Mastery: _____

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make Judgments)
Voltage is electrical pressure measured in volts (V). Current is the flow of electrons in a circuit measured in amps (A). Resistance is the opposition or friction to current flow measured in Ohms (Ω).	$\downarrow I = \frac{V}{R\uparrow}$ $\uparrow I = \frac{V}{R\downarrow}$ Formula shows relationship of current flow and resistance with voltage constant or unchanged.	$I = \frac{V}{R}$ I = current flow V = pressure in volts R = resistance in Ohms $I = 1A = \frac{V = 10v}{R = 10}$ If R is changed to 20 or increased by double, then current flow is decreased to one-half. $I = 0.5A = \frac{V = 10v}{R = 20\Omega}$	If the resistance in a circuit decreases with the voltage remaining the same, then current flow must increase as a result. The current flow as a result of electrical pressure will always be inversely proportional to the resistance change in the circuit.	Refer to b.3, Criterion Measure.	

FORM K-2

Course/Unit: Electronics

T.P.O. # b.3

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	A visual aid should be constructed using small pumps, glass (plastic) tubing, and flow meters to simulate voltage, amps, and resistance in which the student can observe motion of fluid in lines and read pressure and flow which cannot be observed in normal electrical circuits. Given the necessary recourses, the expertise exists on campus to construct the equipment needed.	

FORM I-2

Curriculum Electronics

Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. B-4 Be able to solve problems that involve the use of multiple and sub-multiple units such as kilo, mega, milli and micro.	No. The student will be able to convert to and from various multiple and sub-multiple units. (70% accuracy)	No. Sample Question: Convert 25 milliampere to the equivalent amount in microamperes.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics
T.P.O # B-4
Level of Mastery: Synthesis

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1. The meaning in relation to decimal position: a. units b. multiples c. sub-multiples d. kilo e. mega f. milli g. micro h. nano i. pico j. exponents k. pos powers l. neg powers m. add of exponents n. subtraction of exponents o. multiplication of exponents p. division of exponents 2. Conversion between d through g.	1. Explain the difference between: a. milli-micro-nano b. kilo-meg 2. Explain: a. exponents b. pos-neg exponents and how they relate to the location of the decimal point.	1. Determine the proper units necessary for the problem at hand. 2. Determine the units desired for answer.	1. Convert various units to a common unit, for example, "V" to volts, "R" to Ohms, and "I" to amperes. 2. Solve problem and convert answer to the needed units if necessary.	Solve problem such as $I = \frac{V}{R}$ where: V = millivolts (10^{-3}) R = kilo-ohms (10^{+3}) I = micro ampere (10^{-5})	

FORM K-2

Course/Unit: Electronics

T.P.O. # B-4

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	See recommendations made for B. 1, Ohm's Law.	

FORM I-2

Curriculum Electronics

Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. B-5 Student will be able to perform basic math functions using an electronic calculator.	No. The student will solve representative problem by use of an electronic calculator. (70% accuracy)	No. Sample question: Use your calculator to find θ, when XL = 1000Ω and R = 1000Ω in a series circuit.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics

T.P.O # B-5

Level of Mastery: Evaluation

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1. The basic order of operation of your calculator. 2. The labeling of the various keys. 3. The operation of any special functions such as: a. memory b. conversions c. exponents d. programming e. roots/squares 4. Power supply of calculator (battery).	1. Explain the operating system of your electronic calculator. 2. Explain how information is entered into your calculator.	1. Determine the proper formula for the problem given. 2. Adapt the formula to the format of your electronic calculator.	1. Determine the variables of the problem. 2. Determine how to properly enter the information into the calculator.	1. Decide what unknowns can be found. 2. Decide the proper order of solution of the unknowns.	Decide the proper sequence necessary to solve a given problem within the abilities of your calculator.

FORM K-2

Course/Unit: Electronics

T.P.O. # B-5

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	Set up a lab equipped with algebraic operating system calculators and drill students on operating techniques, i.e., chain calculations, exponents (scientific notation). Calculators should have basic 4 functions, exponents, square and square root, trigonometry functions (sin, cos, tan, etc.). In order to increase proficiency with calculators, basic math defined in General Recommendations is required. The calculator does not replace mathematical knowledge. The lab should push how to plan the attack of overall problems and be able to recognize when errors are made en route.	

FORM I-2

Curriculum Electronics

Course/Unit Title ER 51, RT 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. C-1, Series Circuit The student will be able to understand the relationship between applied voltage, resistance(s) and current in a series circuit.	No. C-1, Series Circuit The student will find the total resistance in the circuits, then solve for I total using Ohm's Law, with a given value of V total. Student must have 70% or better, correct, to pass.	No. C-1, Series Circuit Find the total resistance for each circuit. With V total given, solve for I total, using $I_T = \frac{V_T}{R_T}$.

FORM J-2

COGNITIVF/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics

T.P.O # C-1

Level of Mastery: Synthesis

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
Ohm's Law and its forms	Explain the relationship of V, I, and R.	Calculate the answer and then compare this with measurements made in the Lab.	Identify the component resistances through which I total flows. Identify all known quantities and use forms of Ohm's Law for solution of unknowns.	Solve series circuit problems.	

FORM K-2

Course/Unit: Electronics

T.P.O. # C 1

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
C-1. Already in proper sequence.	TPO, C.1 - Recall from I-2.	See General Recommendations 7, 8, and 9.	

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Curriculum Electronics

Course/Unit Title ~~EP 51, RT 51~~

TERMINAL LEARNING REQUIREMENTS

FORM I-2

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. C-2, Series Circuit Student will be able to solve problems (using more than one resistor connected in a series circuit) to find I total and V_1, V_2, V_3, etc.	No. C-2, Series Circuit The student will find the sum of all the resistors in each series circuit, then solve for I total. Student will find the sum of the individual voltage drops across each resistor equal to the total applied voltage. Student must have 70% or better, correct, to pass.	No. C-2, Series Circuit Find the sum of all resistances in the circuit and solve for I total using Ohm's Law $\left(I_T = \frac{V_T}{R_T}\right)$. Find each individual voltage drop by using the formula $V_1 = R_1 \times I_T$, $V_2 = R_2 \times I_T$, etc.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

Course/Unit: Electronics
T.P.O # C-2
Level of Mastery: Synthesis

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
Ohm's Law and its forms.	Explain the relationship of V, I, and R. Explain that the sum of all voltage drops in a Series Circuit equals the total applied voltage.	Calculate the answers, and then compare these with measurements made. in the Lab.	Identify the component resistances through which I total flows. Identify all known quantities and use appropriate forms of Ohm's Law for solution of unknowns.	Solve Series Circuit problems which contain multiple resistances.	

FORM K-2

Course/Unit: Electronics

T.P.O. # C-2

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
C-2 Already in proper sequence	TPO C-2 Recall from I-2	See General Recommendations 7, 8, 9.	

Curriculum Electronics

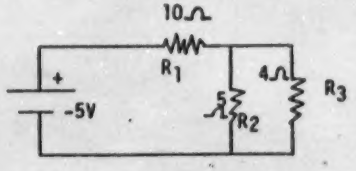
Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

FORM I-2

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. C-3 Be able to determine the various currant paths through electronic circuits by analyzing the schematic diagram.	No. Be able to analyze a circuit drawing, schematic, and determine various values of V, I and R for the components that make up that circuit. (70% accuracy)	No. Sample Question: What is the value of a current flow through "R_3" in the circuit shown? 

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Course/Unit: Electronics ER 51

T.P.O # C-3

Level of Mastery: Analysis

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1. Direction of current flow: a) series b) parallel 2. Ohm's Law 3. Kirchoff's voltage drops 4. Units/sub-units for V, I and R. 5. Schematic symbols for V, I and R. 6. Schematic drawing that represents resistors, conductors, batteries and points connected together.	Explain: 1. Current flow in a "series" circuit. 2. "I" is constant in "series" circuit. 3. Voltage drops add in "series". 4. Current flow in "parallel" circuit. 5. Voltage is constant in "parallel". 6. Currents add in parallel circuit. 7. Kirchoff's Law for voltage drops.	1. Determine the relationship of R_2 and R_3; i.e., they are "parallel" 2. Determine relationship of the total of (R_2-R_3) and R_1; i.e., they are in series. 3. Determine R total for circuit using proper R total formulas. 4. Determine I_T by Ohm's Law. 5. Determine voltage drops across R_1, R_2 and R_3 using Ohm's Law and Kirchoff's Law for voltage.	1. Solve Ohm's Law problem for R_3 and find I. $I_{(R_3)} = \frac{V_{(R_3)}}{R_3}$		

FORM K-2

Course/Unit: ER 51 Electronics

T.P.O. # C-3

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	See General Recommendations 7, 8, and 9.	

FORM I-2

Curriculum Electronics

Course/Unit Title ER 51, RT 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. E-1 Series-Parallel Circuit Student will be able to understand the effect of connecting resistances in parallel, with total circuit current dividing to provide individual currents in each of the individual resistive branches. Student will understand effect of connecting resistances in series, where the total circuit current flows through each resistance.	No. E-1 Series-Parallel Circuit Student will find R total for two or more resistances connected in parallel and two or more resistances connected in series. 70% or more correct answers will constitute passing grade.	No. E-1 Series-Parallel Circuit Find the R total for each parallel combination of resistances using the reciprocal formula: $R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$, etc. Find R total for each series combination of resistances using the formula: $R_{total} = R_1 + R_2 + R_3$, etc.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

Course/Unit: Electronics

T.P.O # E-1

Level of Mastery: Synthesis

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
Formulas for resistances connected in series, and resistances connected in parallel.	Explain the effect of resistances connected in series, and of resistances connected in parallel, with emphasis on branch currents.	Calculate the answers and compare this with measurements made in the Lab.	Identify the component resistances through which current flows in series connections, and the component resistances which carry branch currents in parallel circuits.	Solve series-circuit and parallel-circuit problems for R total.	

FORM K-2

Course/Unit: Electronics

T.P.O. # E-1

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
E-1 Already in proper sequence.	TPO E-1 Recall from I-2.	See General Recommendations 7, 8, and 9.	

FORM I-2

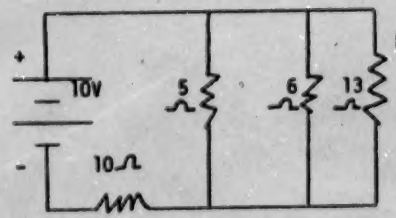
Curriculum Electronics

Course/Unit Title ER 51

TERMINAL LEARNING REQUIREMENTS

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. E-2 Student will be able to determine parallel relationships that in series-parallel combination circuit.	No. Student will be able to compute parallel current flow and voltage drops for various circuit combinations. (70% accuracy)	No. Sample Question: Calculate the total resistance and current for the circuit shown.  Fig. 1

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

Course/Unit: Electronics

T.P.O # E-2

Level of Mastery: Application

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
1. Currents in a parallel circuit are additive. 2. Voltage drops in a series circuit are additive.	2. Must be able to apply the rule that the sum of the currents leaving a point must equal the sum of the currents arriving at the point. 2. The voltage across each branch in a parallel circuit is the same. 3. The sum of the voltage drops in a series circuit are equal to the source.	1. Determine path for current to flow through parallel circuit. Path splits and must return after passing through each branch of the circuit. 2. Recognize that the parallel total circuit (after the branches are combined) becomes an element of the remaining circuit.			

FORM K-2

LEARNING SEQUENCE

Course/Unit: Electronics

T.P.O. # E-2

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
Same as J-2 Recall	Same as I-2 Criterion Measure	See General Recommendations 7, 8 and 9.	

Curriculum Electronics

Course/Unit Title ER 51, RT 51

TERMINAL LEARNING REQUIREMENTS

FORM I-2

Curriculum Analyst _____

Date _____

Terminal Performance Objectives	Criterion Statement	Criterion Measure
No. E-3 Series-Parallel Circuit Student will be able to understand the relationship between applied voltage, resistances, multiple current paths, individual voltage drops, and I total.	No. E-3 Series-Parallel Circuit Student will find R Total and I Total for the circuit. 70% of answers correct will constitute passing grade.	No. E-3 Series-Parallel Circuit Find the R Total for each circuit. Given either I Total or V Total, solve for the unknown using Ohm's Law.

FORM J-2

COGNITIVE/PSYCHOMOTOR/AFFECTIVE ANALYSIS
FOR
TERMINAL PERFORMANCE OBJECTIVE

Refer to: Taxonomies--SAFE Manual, pps. 143-46
Handouts on Taxonomies

Course/Unit: Electronics
T.P.O # E-3
Level of Mastery: Synthesis

RECALL (Memory)	COMPREHENSION (Explanation)	APPLICATION (Apply to simulated or real situation)	ANALYSIS (Break down into parts)	SYNTHESIS (Pull together elements/ solve problems)	EVALUATION (Make judgments)
Ohm's Law and its forms, and formulas for series and parallel combinations of resistances.	Explain the concepts involved in connecting series and parallel combinations of resistances.	Calculate the voltage drop across each resistance and the current through each resistance in the series-parallel circuit; together with I Total, given V Total. Calculate R Total. Compare answers with measurements made in Lab.	Identify the current path that carries I Total and each branch current path. I Total equals the sum of the branch currents. Calculate R Total for series-parallel circuits. Calculate voltage drops.	Solve series-parallel problems for R Total and I Total, given V Total.	

FORM K-2

Course/Unit: Electronics E-3

T.P.O. #

LEARNING SEQUENCE

LEARNING STEPS	RESPONSE/EVALUATION	ALTERNATE METHODS/MEDIA	METHOD/MEDIA SELECTION
E-3 Already in proper sequence.	TPO E-3 - Recall from I-2.		

RESEARCH AND DESIGN

PROJECT: MOBILITY

STEPS OF CURRICULUM ANALYSIS

STEP 5

THE FINAL STEP TAKEN BY THE TEAM IS TO PULL TOGETHER ALL THEIR FINDINGS AND RECOMMENDATIONS INTO ONE DOCUMENT. THIS DOCUMENT, IN COMBINATION WITH THE METHODS/MEDIA ALTERNATIVES IDENTIFIED IN STEP 4 WILL BE THE BASIS FOR SPECIFIC PROGRAM CHANGES TO BE IMPLEMENTED IN PHASE III OF THE RESEARCH AND DESIGN PROJECT. IN COMBINATION WITH THE OTHER PORTIONS OF THE PROJECT, I.E., COUNSELING AND GUIDANCE, MANAGEMENT PLANS, EVALUATION AND AUDIT SYSTEMS, THE CURRICULUM DESIGN RECOMMENDATIONS SHOULD ELIMINATE THE HURDLES TO SUCCESS BEING ENCOUNTERED BY DISADVANTAGED AND/OR HANDICAPPED VOCATIONAL EDUCATION STUDENTS. IF THEY DO NOT, THEY WILL BE REANALYZED AND REVISED UNTIL THEY DO.

STEP 5:

A) DEFINE SPECIFIC RECOMMENDATIONS OF PROGRAM/COURSE CHANGE TO ELIMINATE THE IDENTIFIED PROBLEMS AND PRODUCE THE REQUIRED MASTERY.

RESEARCH AND DESIGN PROJECT
ELECTRONICS

General Recommendations

I. Basic Skills

Electronics is a highly technical, mathematical, complex vocational area. It requires students to master a broad range of abstract scientific theories. The student, therefore, who enters the program without the basic mathematical, reading, or study skills required to master and apply these theories finds him or herself behind and confused from the first day of class. There is a need, therefore, for the following basic skill support systems to be developed:

a. A basic math program should be developed to reinforce the following math operations: numbers, fractions, decimals, roots, squares, equations, etc., plus exponents. A similar program should be created to develop basic reading comprehension and basic work/study skills in students.

b. Students deficient in math and reading should be counselled to take a above preceding entry into Basic Electronics ER 51.

c. Some phase of special services has to deal with establishing the relevance to disadvantaged students of abstract concepts and abstract magnitudes of numbers in order for them to be successful in Electronics.

II. Three Dimensional Models of Abstract Electrical Theories

The need for concrete examples of abstract concepts exists for disadvantaged students throughout the Electronics curriculum. Very few models exist in the commercial market place. The technical competence already exists on campus to build any needed models and examples. The Committee recommends that additional resource money be made available to take advantage of these capabilities. We are able to provide all needed specifications if the required resources can be made available.

III. Lab Assistant

One of the most viable ways of taking the abstract nature of Electronics and making it concrete is through carefully designed experiments. A large number of such experiments exist. However, the time required to set up these experiments and adjust the necessary equipment limits their availability to the existing faculty.

If a qualified lab assistant were made available to the Electronics Program, he or she could both allow for increased experimentation and personal attention to the disadvantaged student when confusion occurs. Such a person could be utilized throughout the Electronics Program and significantly free the Electronics instructors to provide additional reinforcement and personal attention to those disadvantaged students experiencing difficulties.

IV. Self-Directing Programs

There presently exist no programmed materials to reinforce the key points and problem areas of Electronics. The existing materials are too broad and do not focus on the key elements and problems. The Committee stands ready to create such programming, given the required resources. This would also include a series of lab experiments that the students could use to reinforce their class work.

The Committee wants to create this resource in the Electronics Lab to allow immediate and continuous access by the student. This can be combined with the Lab Assistant to provide the repetition, drill and support that the disadvantaged student requires.

A video cassette recorder, camera, and associate equipment (mics, booms, etc.) could be used by our experienced Electronics staff to produce training tapes for the disadvantaged students in our program. A suggested video cassette recorder is the Sony model VO-2850(A), which is a "commercial" (not "home" type) recorder with editing facilities. The price at this time is $3,000.

Also a tape cassette "player" which can be operated by the students for repeat learning processes is recommended. Students should not be allowed to use the studio-type equipment listed above in order to keep it in good shape for studio-type work. A suggested type would be the home model Sony (price $1500). Two units would be necessary to allow at least two students at a time to observe training tapes.

A camera will be necessary for video taping. A model number is not available at this time, but will be added later. Approximate price is $7,000 with proper lenses.

Also a number of blank cassette tapes would be needed at $25 per tape.

V. Calculator Lab

A major tool utilized by the Electronics student is the calculator. In order to most efficiently and effectively solve problems, the Electronics student must be highly skilled in the basic operations of a calculator, the sequence of entering data into a calculator, and the more complex functions of a calculator.

Those students that experience difficulties in Electronics courses frequently display limited understanding and skills relating to the use of the calculator. We stand ready to identify the programming and the instructional sequencing that would be necessary to create a Calculator Skills Lab if the resources needed to support the development, hardware and software requirements of such a Skills Lab are available.